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Ministry of Environment, Fisheries Branch, 2204 Main Mall, U.B.C., Vancouver, B. C. V6T 1W5

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Abstract

Rempel, M. H., R. W. Land, L. W. Mitchell and B. R. Ward. Wild and Hatchery Steelhead and Cutthroat Trout Populations of the Little Campbell River, B. C., 1983. Fisheries Technical Circular No. 62.

A fish counting fence was operated for the second year at the Little Campbell River. The main objectives were to (1) evaluate the migratory success of hatchery steelhead and cutthroat smolts stocked at various sites upstream of the fence and (2) provide data on the production of steelhead and searun cutthroat trout smolts that would be typical of low gradient fertile streams in the lower mainland of British Columbia.

Six thousand nine hundred steelhead trout smolts (mean weight 124 g) and 2000 cutthroat trout smolts (mean weight 112 g) were stocked during late April in 1983 into the Little Campbell River, 2 to 7 km upstream of the counting fence. Fifty-seven percent of the steelhead and 39% of the cutthroat migrated downstream through the counting fence. Low migration of these hatchery smolts demonstrated for the second year a serious problem of residualism and pre-migration mortality. Electrofishing surveys have confirmed that residualism is a main factor. Residualism is associated with precocious sexual development which is probably induced by rapid growth to a large size (117 to 124 g) in the hatchery.

Wild smolt yields were $0.085/m^2$ and $0.011/m^2$ for steelhead and cutthroat trout respectively for the total 27,000 m^2 of 'wetted' mainstem area above the counting fence, although some of the cutthroat are produced in small tributaries. Yield of steelhead smolts in 1983 increased by 85% over 1982, reflecting the high underyearling population in the stream during summer in 1982. Wild cutthroat smolts remained approximately the same.

Forty-two percent and 50% of the age composition of steelhead and cutthroat smolts respectively were comprised of age 1. migrants during 1983 compared to approx. 60% in 1982. This contrasts with the strong dominance in age 2. or 3. smolts in most coastal streams in the Pacific Northwest.

Acknowledgements

The continuing enthusiastic interest and support of the Semiahmoo Fish and Game Club deserves the utmost credit; without such a group this work would not have been possible. Several club members were particularly helpful, including Bob Oswald, Gerry Falk, Ed Kendel.

Pat Slaney, senior research biologist with the Fisheries Research Section of the Fisheries Branch, provided the thrust, direction and fervor to effectively coordinate many of the activities. Along with Joe Kambietz of the Department of Fisheries and Oceans, staff of the Fish and Wildlife Branch including Brian Clarke, Rob Knight, and in particular, Peter Caverhill, helped with several tasks. Assistance from staff of the Fraser Valley Trout Hatchery is gratefully acknowledged. Eric Parkinson improved the report with his edit and review.

Doris McKay typed the draft and final report. Bruce Ward wrote the report and assumes responsibility for errors or omissions.

Introduction

Low gradient streams associated with agricultural areas in the lower mainland of British Columbia support important steelhead and searun cutthroat trout fisheries which have declined in the past decade particularly in the 1970's (Steelhead Harvest Analysis). Causes of these declines are uncertain, but are considered to be the interactive impacts of urban land use, agricultural land use and overfishing. The Little Campbell River, 50 km south east of Vancouver, is typical of these streams with its nutrient enriched waters, flows affected by ground water, and mixed agricultural and residential land use in the watershed.

These characteristics contrast with most other coastal trout streams which are steeper in gradient and more oligotrophic as a result of higher precipitation and mountainous bedrock terrain. To more effectively manage searun trout fisheries it is essential to understand the differences in productive dynamics between these different types of streams. In 1981, the Semiahmoo Fish and Game Club, in cooperation with the federal Department of Fisheries and Oceans and the provincial Fisheries Branch, constructed a permanent counting fence on the Little Campbell River. Since 1979 the Fisheries Branch has stocked cutthroat fry, fingerlings and smolts in the mainstems or tributaries of several B. C. streams. The adult and smolt trapping facility provided an opportunity to examine the population trends and productive capacity of wild trout as well as migration success of stocked hatchery trout on this stream. In addition, the effectiveness of restrictive sport fish regulations, recently invoked on lower mainland streams, could be evaluated over several years.

Objectives of the studies were to:

1. Determine the percentage migration and residualism of hatchery steelhead and cutthroat smolts and assess possible causes for failure of these fish to migrate.

2. Obtain annual counts or mark and recapture estimates of adult steelhead and cutthroat trout migrating through the fence.

3. Obtain annual estimates of smolt yield (numbers and weights per m^2) of wild steelhead and cutthroat trout produced in stream sections above the fence and eventually assess the survival and contribution of cutthroat trout stocked as marked fingerlings or fry.

4. Obtain juvenile life history data for steelhead and cutthroat trout including length, weight and age distributions, timing of migration and annual variations in these characteristics.

5. Determine annual potential egg deposition, fry density, wild parr density and hatchery "parr" density (i.e.,

residuals).

Study Area

The Little Campbell River, located in Surrey and Langley municipalities, is the most southwesterly of lower mainland British Columbia streams (Fig. 1). Deleeuw and Stuart (1981) report that percentage land use by stream length is 56% agriculture, 19% recreational parks, 13% residential, 10% undeveloped and scattered commercial and industrial land zones. Precipitation, greatest during autumn and winter, is about 104 cm annually (Peterson 1966). Maximum daily discharge (drainage area of 63.7 km^2) was reported as 14.12 m^3/sec, average about 1 m^3/sec, and an extreme minimum of 0 (Water Survey of Canada). Licensed water extractions potentially account for up to 1 m^3/sec. This low gradient (range 1.1 to 6.8 m/km), nutrient rich system (nitrate N 1.04 mg/l, orthophosphate .043, M. Clark, B. C. Waste Management Branch, pers. comm.) has potentially 27,000 m^2 (5.4 km) for salmonid rearing above the counting fence during summer flow, in addition to 7 km located downstream (Fig. 1).

Methods

Operation and maintenance of the Little Campbell River counting fence, located 7 km upstream of the river mouth, was cooperatively conducted by the Semiahmoo Fish and Game Club, the B. C. Fisheries Branch and the Department of Fisheries and Oceans. Adult steelhead were noted for sex, and enumerated. A small hole (5 mm) was punched in the operculum of hatchery and wild adults, which regenerates in 2 to 3 months, to estimate the total population size from recaptured kelts migrating downstream, using the modified Peterson estimate:

$$N = \frac{(M + 1)(C + 1)}{R + 1}$$

where:

N = estimated population size
C = total capture downstream
R = number of recaptures
M = number of fish marked upstream

Male and female estimates were made separately, then added. Six to seven scales were removed from the area behind and below the dorsal fin, above the lateral line. Age from scales was interpreted similar to methods of Horncastle (1981) and Narver and Withler (1971).

Steelhead smolts (mean, 124 g) were stocked above the counting fence on April 20th (approx. 3000 smolts per site; Appendix 1). Approximately 2000 cutthroat smolts (mean, 112 g)

were released with the steelhead groups about 3, 5 and 7 km above the counting fence.

Daily enumeration of wild and hatchery smolts at the fence began by mid-April. Twice per week, lengths, weights and scale samples were obtained from steelhead and cutthroat, randomly selected from wild and hatchery migrants. Fence efficiency was checked by releasing 120 steelhead smolts (caudal fin clip) upstream and noting the recapture success.

Standing crop during low summer flow was estimated by sampling during August 0.3 and 5 km upstream of the counting fence. Representative 100 m sections in each site were enclosed with nets and electroshocked (Smith-Root Type VIII-A). Captured fish were marked with an upper caudal fin clip and returned to the site. One hour later a second sample was removed by electroshocking and population estimates obtained. Hatchery smolts in the sample which failed to migrate in the spring (residuals) were sacrificed to determine sex and development, length and weight. Density estimates were compared with 1982 and with other systems for which data was available.

Results and Discussion

The adult steelhead run of 1982/83 (Nov to April) was estimated as 215 for wild fish and 121 for hatchery fish. The recapture success was 56% and 54% for wild and hatchery males, 90% and 70% for wild and hatchery females respectively. These statistics were affected by erroneous adipose fin clipping of 3 male and 4 female wild upstream migrants, thus deflating the wild and inflating the hatchery population estimates. The most common age of wild fish was 2.2 based on scale samples (Table 1), similar to Chapman (1958), Peterson and Lyons (1968), and Narver and Withler (1971), females outnumbering wild males 1.6 to 1. As in the Alsea River (Chapman 1958), hatchery fish returned mainly after two years but were smaller than wild adults of the same ocean age. This trend should be examined further by comparing wild and hatchery smolt size at exit and adult size at return to determine if growth rates differ. The number of adults sampled for scale analysis should be increased to more fully define length, sex and age composition of the run.

Adult cutthroat trapping did not allow a population estimate since 5 fish were marked upstream and 5 unmarked kelts collected downstream.

Table 1. Mean length at age and range (mm) for Little Campbell River hatchery and wild steelhead, 1982-83. Repeat spawners not included. Based on scale samples.

AGE	1.1		1.2		1.3	
SEX	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
HATCHERY						
Mean Length	454	775	681	646	690	-
N	7	2	20	23	1	-
Range	410-540	710-840	430-750	600-750	-	-
WILD						
Mean Length	-	698	690	655	832	765
N	-	5	14	23	4	8
Range	-	660-750	620-780	570-810	790-900	650-810
	2.1		2.2		2.3	
WILD						
Mean Length	602	742	689	678	900	756
N	4	5	15	24	1	3
Range	450-750	660-820	600-750	520-900	-	730-800

The timing of the Little Campbell River smolt migration (Fig. 2) is intermediate between more northerly B. C. streams (Keogh River; Ward and Slaney 1979) and streams further south (Chambers Creek; Larson and Ward 1955). The timing of the hatchery steelhead and cutthroat smolt migrations were similar to each other (Fig. 3, 4) but earlier than the 1982 migration (Appendix III). Efficiency of trap operation was difficult to measure due to problems in identification of recaptured marked steelhead, mortality and residualism, since only 58 of 120 released smolts were noted. Since trapping was similar to 1982 (Rempel and Land 1983), the 1982 efficiency of 80% was assumed and capture numbers were thus adjusted (Table 2). Large coho smolt should be marked and released in the future to determine capture efficiency.

Table 2. Number of fish enumerated downstream, Little Campbell River 1984 (fence counts expanded by 20%).

	Steelhead	Cutthroat
Wild	2305	290
Hatchery	3971	779

Wild steelhead smolt yield was high (0.085/m^2, Table 3), almost double the 1982 yield (Appendix II), four times Keogh River capability (P. A. Slaney, pers. comm.) and more than ten times Carnation Creek (Narver and Anderson 1974). However, cutthroat trout smolt yield, unchanged from 1982 (0.011/m^2), was low compared to Coghlan Creek (0.09/m^2) and in prime habitat of Colquitz Creek (0.13/m^2, R. Ptolemy, pers. comm.). The combined cutthroat and steelhead yield (0.096/m^2) in the Little Campbell River was similar to the mean combined smolt yield (0.08/m^2) from the Salmon River in the Lower Mainland (3 years; R. Ptolemy, pers. comm.). Cutthroat smolt yield does not include tributary area, and mainstem rearing may be limited by competition with steelhead, thus cutthroat smolt yield per unit area may be underestimated.

Table 3. Little Campbell River wild smolt yield above the fence 1983, based on mainstem area.

	#/m	#/m^2	g/m*	g/m^2
Cutthroat	0.054	.011	2.85	0.57
Steelhead	0.427	.085	19.76	3.95

* mean wt. steelhead smolt = 46.3 g; mean wt cutthroat smolt = 53.05 g

Seaward migration of hatchery smolts through the counting fence was low relative to numbers released upstream. Only 57% of hatchery steelhead and 39% of cutthroat were recaptured at the trap.

Table 4. Freshwater age composition, length and weight at age of wild steelhead and cutthroat smolts, Little Campbell River 1983, based on scale samples.

	Steelhead			Cutthroat		
AGE	1.	2.	3.	1.	2.	3.
%	42	58	0	50	50	0
(n)	(76)	(106)		(19)	(19)	
Length (mm)	156.8	178.6		162.1	194.9	
S.D.	15.8	17.7		14.3	8.7	
Weight (g)	37.1	52.9		38.5	67.6	
S.D	12.1	16.2		21.2	21.5	

The large size of hatchery smolts compared to wild (Figs. 5, 6) could be indicative of the probability of occurrence of mature male parr (Slaney and Harrower 1981; Dalley et al, 1983) and thus decreased smolt output relative to fish released, particularly for cutthroat. Hatchery cutthroat (mean 117 g) were almost twice the mean weight of 2 yr old wild cutthroat smolts (Table 4).

Osterdahl (1969) suggests comparisons between wild and hatchery smolts should be made separately for each sex and future studies should consider the suggestion.

Fish classified as parr (i.e., non-silver) were smaller at age than smolts. Steelhead parr age 1 and 2 averaged 126.8 and 157.6 mm (n = 27 and 5) respectively. Age 1+ cutthroat parr were 118.4 mm (n = 5) at capture.

Stream sampling during August confirmed that residualism was a significant factor with hatchery released smolts (Table 5). Approximately 4% of the accessible stream by length (above the trap) was sampled, and this was assumed to be adequate. While densities of coho fry increased over 1982, steelhead fry dropped and, as in 1982, wild cutthroat parr were almost non-existant. Trout densities in 1983 decreased from 1982 in the upper section, except residualized smolts.

Table 5. Densities (no./m^2) of juvenile salmonids in the Little Campbell River, August, 1983.

Distance upstream	Section A 0.3 km	Section B 7 km	Average
Wild			
Coho fry	2.74	0.61	1.68
Steelhead fry *	0.96	0.32	0.64
Steelhead parr	0.23	0.12	0.18
Cutthroat parr	0	0.02	0.01
Hatchery			
Steelhead and Cutthroat parr	0.03	0.11	0.07

* some cutthroat fry possibly included

Hatchery smolts that failed to migrate accounted for approximately 8 and 62% of the total salmonid biomass in Sections A and B respectively. Bailey et al (1980) noted that larger males in the lower mode of hatchery fish length frequency distribution tend to be precocious Atlantic salmon parr. Many hatchery reared cutthroat and steelhead in that mode would likely fail to migrate (Schmidt and House, 1979). Sex ratios of hatchery fish sampled as residuals in August 1983 were male dominant (Table 6). The impact on wild fish can be significant since fry and parr may be cannibalized or displaced to less

favourable habitat and further, residuals fail to smoltify to an equal degree the following year (Slaney and Harrower 1981). Hatchery smolt releases should be directly below the counting fence in the future. The wild male resident (i.e., non-migrant sexually maturing) component of steelhead density requires further elucidation.

Table 6. Sex ratios and gonad index of residual hatchery trout in the Little Campbell River 1983.

	Sex Ratio (M:F)	Gonad Index-Mean (0-4)	
		Males	Females
Hatchery Steelhead	3.9:1	2.6	1.9
Hatchery Cutthroat	1.22:1	1.4	2.1

Gonad Index:
0 - zero development
1 - glandular expansion at anterior end
2 - glandular expansion throughout most of gonad
3 - gonads significant size and egg size ∿1 mm, testes very white
4 - approaching spawning condition

Recommendations

Collection of population data from the Little Campbell River confirms this system as having a highly productive potential. As an experimental stream it is an ideal comparison to more oligotrophic systems with ongoing life history - production studies (Keogh River) and allows an opportunity to evaluate a number of hatchery stocking options as well as, in the future, stream habitat improvement. Continuation of trapping and stream sampling of the populations is highly recommended.

This year's efforts validate results of 1982 in that smolt yield was high for steelhead in streams in British Columbia, though cutthroat were low. These fish migrated early (by age 1 and 2) following rapid growth in the stream. Residualism of hatchery releases continues to be a serious problem and a review of stocking locations for hatchery smolts is required.

Recommendations are:

1. No stocking of steelhead smolts, fry or fingerlings for 6 km above the counting fence. Recent adult escapements (> 500 fish in 1984) adequately recruit this area with fry. Rather, stocking of marked fingerlings above this area, and their enumeration at the fence in 1985 and 1986 is an alternative.

2. Continue evaluation of cutthroat smolt stocking above the fence in 1984; other options, including fry and fall

fingerlings (mainstem and tributaries) should be evaluated over several years.

3. Continuous water level and temperature records would enhance the data base and perhaps help explain some of the variability in yield and standing crop.

4. Opportunities for habitat improvement (e.g., "complexing") should be assessed in 1984 within the 5.4 km above the counting fence. The smolt fence and club participation provides an opportunity to confirm the benefits of enhancement structures tested elsewhere (e.g., Ward and Slaney 1979).

Enhancement of salmon and trout in the Little Campbell River should proceed utilizing a mixture of natural and artificial techniques to ensure the genetic and ecological integrity of the wild salmonid populations is not degraded.

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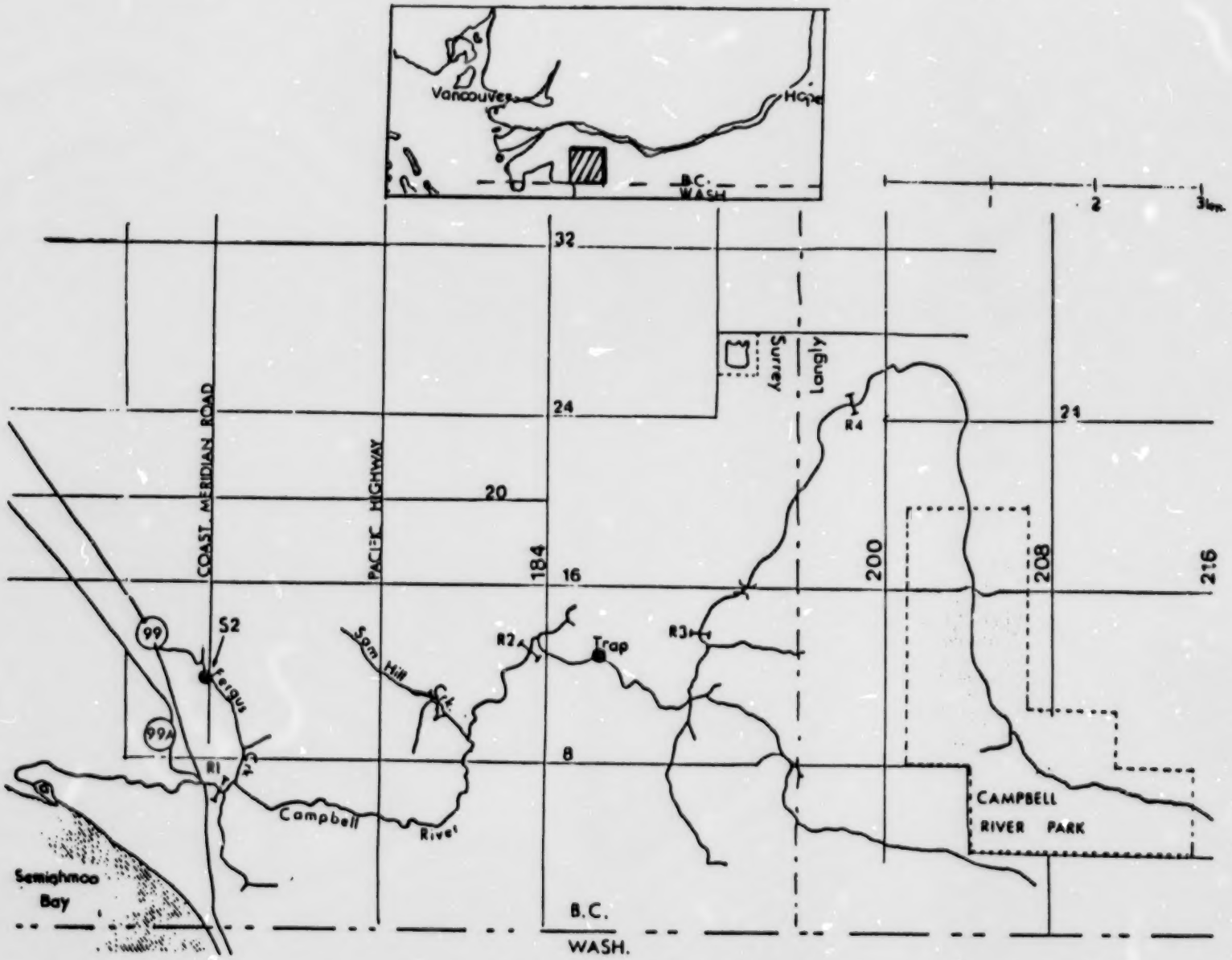


Fig. 1. Little Campbell River watershed, showing main roads, tributaries and trap locations.

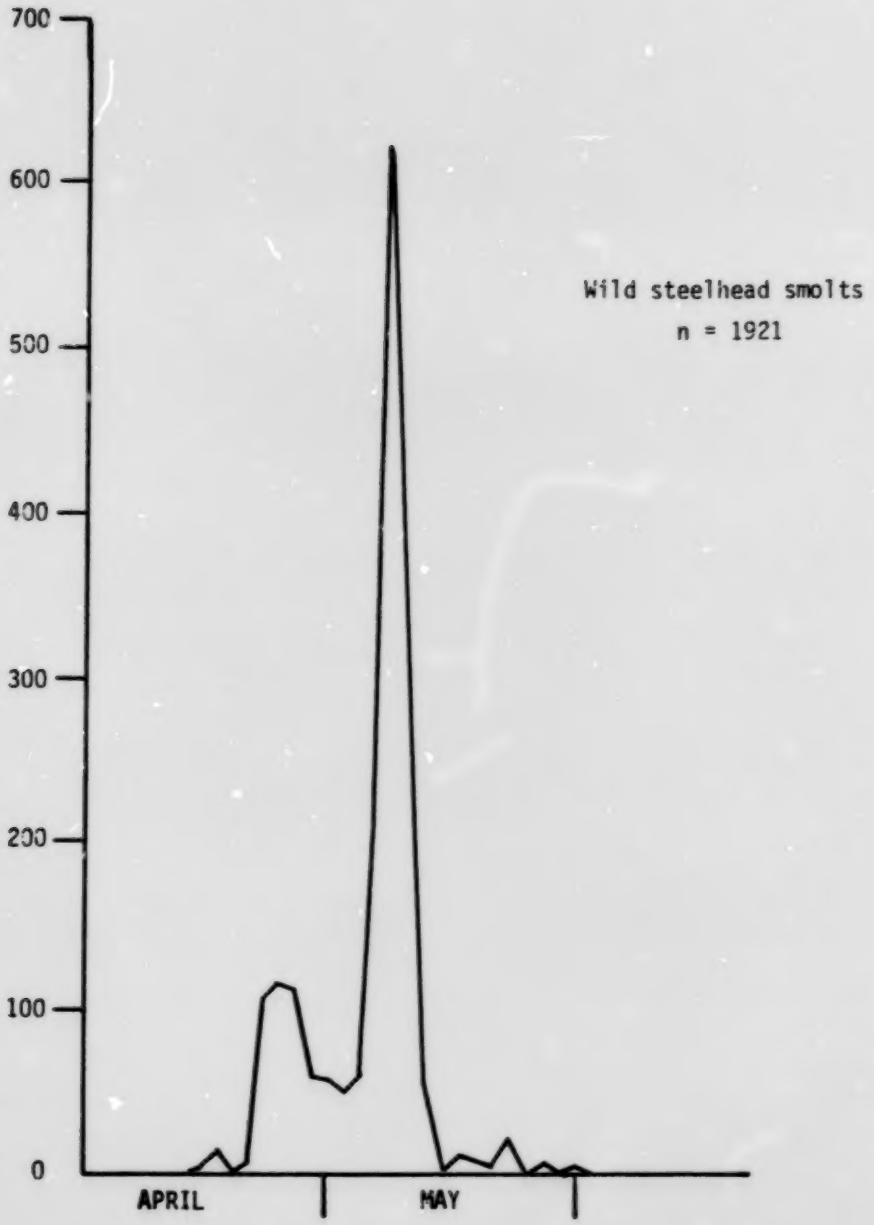


Fig. 2. Seaward migration of wild steelhead smolts from the Little Campbell counting fence in 1983.

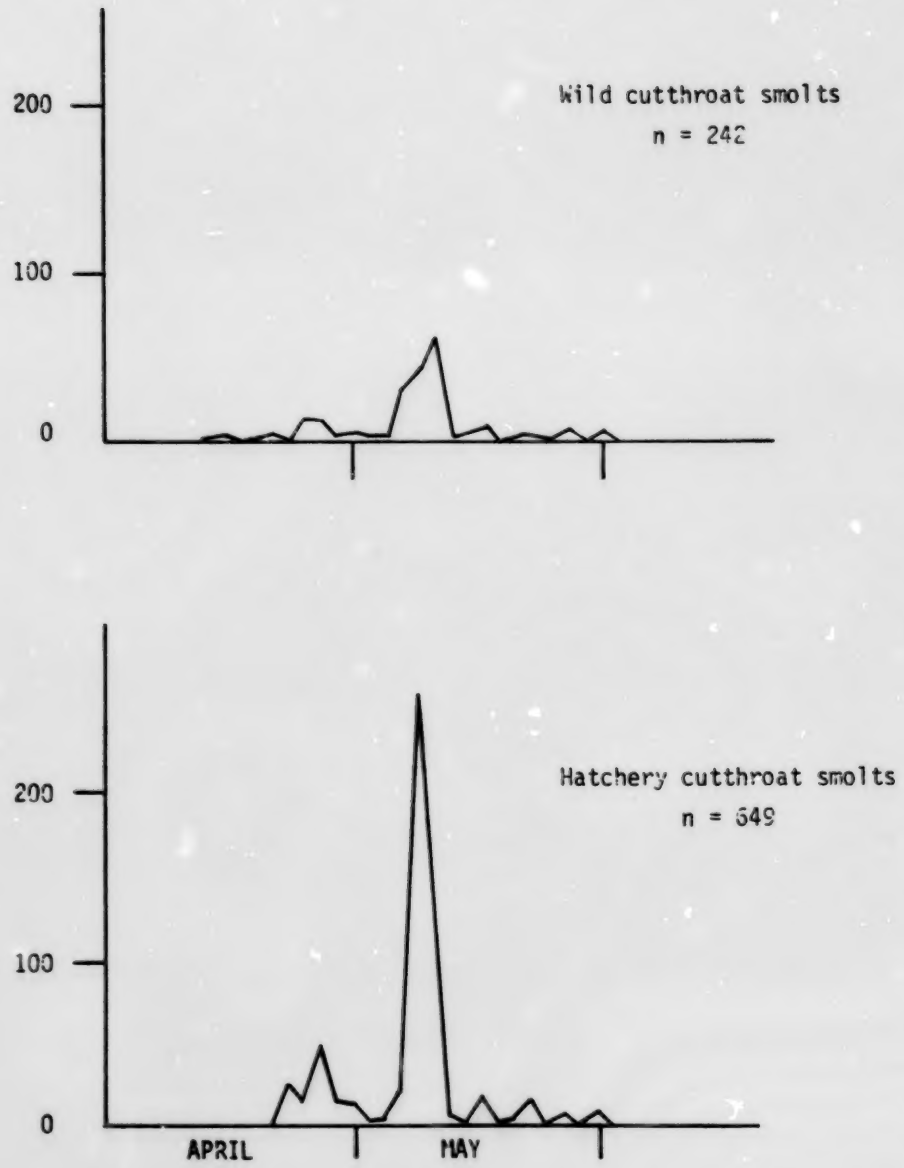


Fig. 3. Seaward migration of cutthroat smolts from the Little Campbell counting fence in 1983.

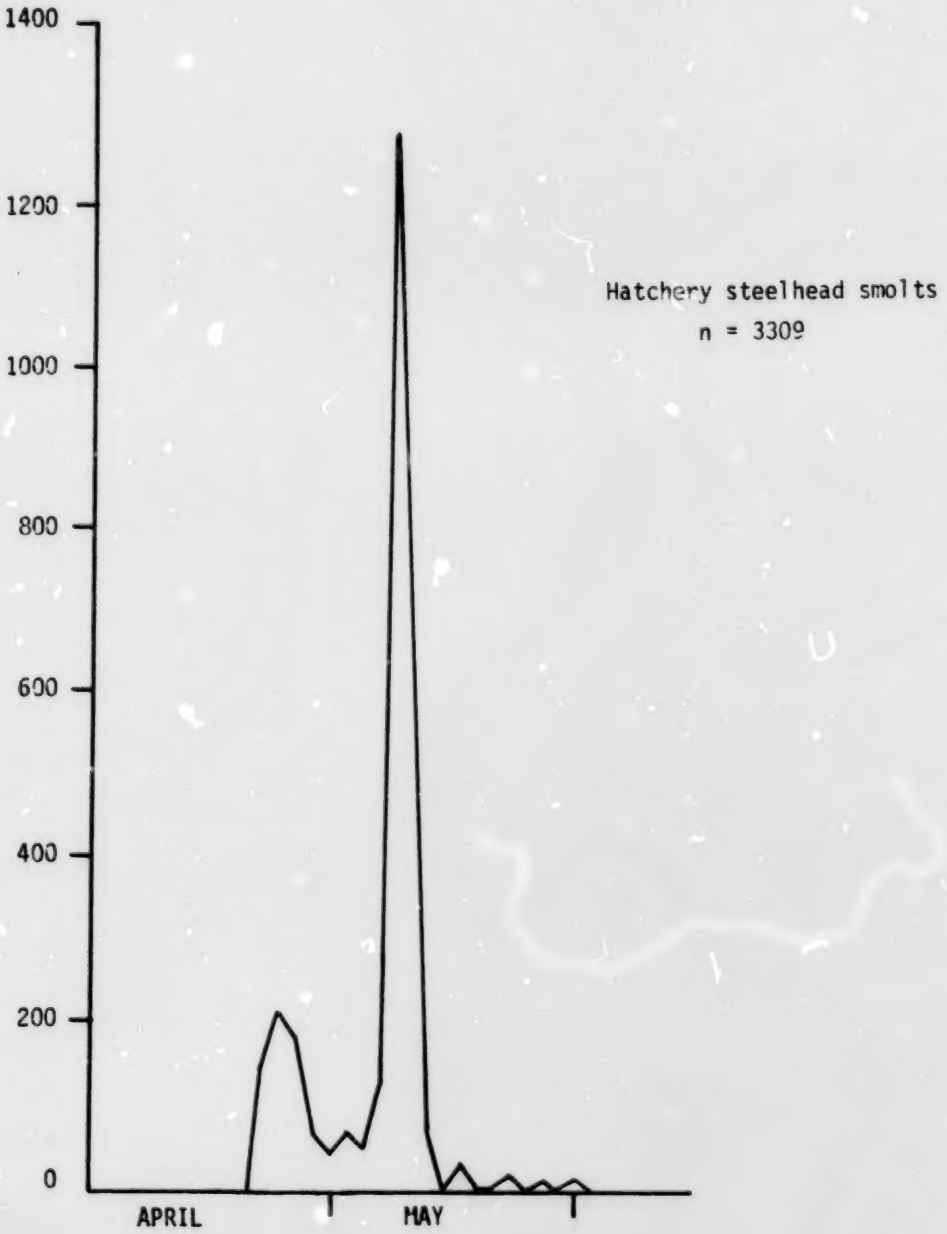


Fig. 4. Seaward migration of hatchery steelhead smolts from the Little Campbell counting fence in 1983.

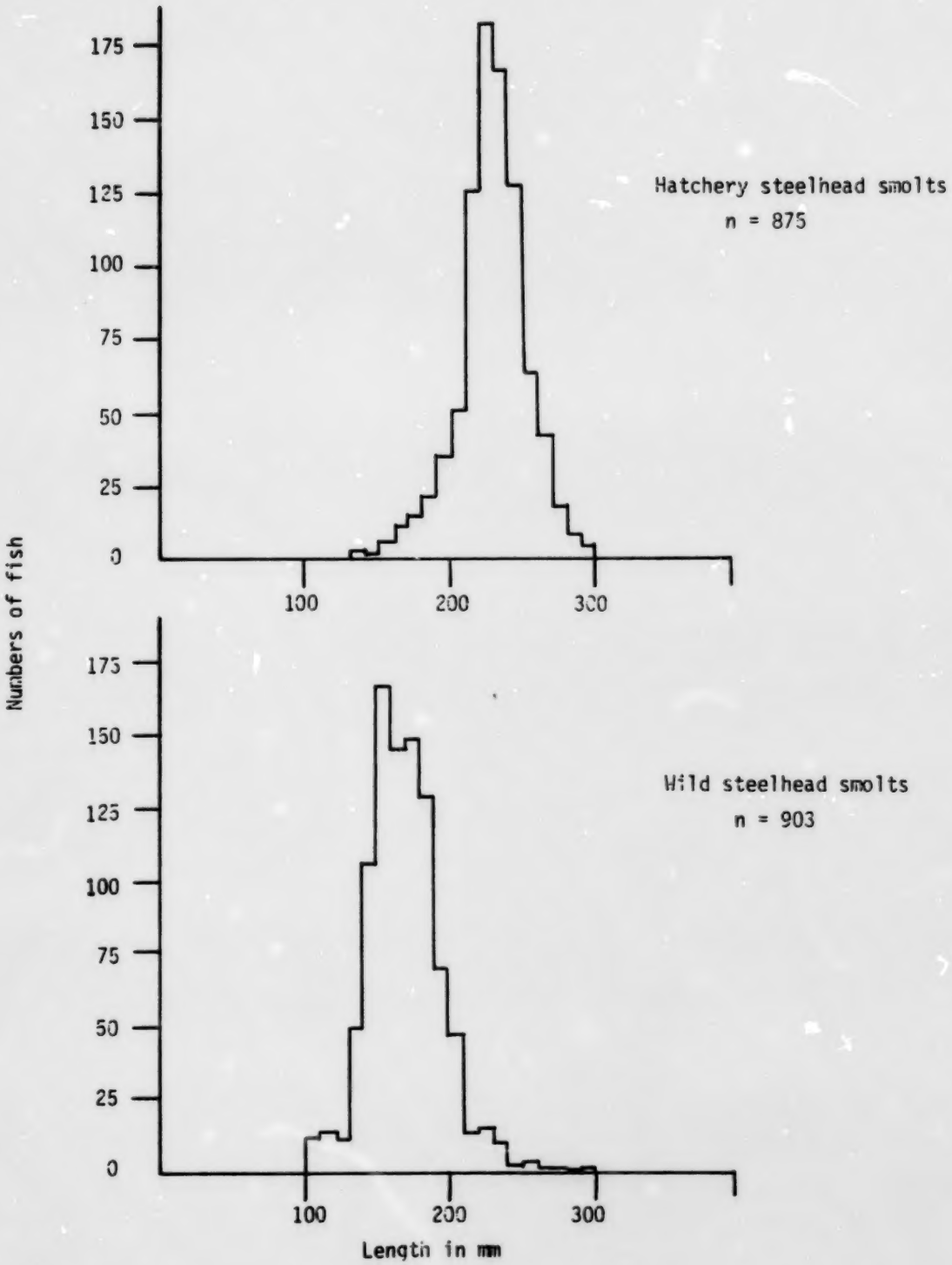


Fig. 5. Length frequency of steelhead migrating downstream at Little Campbell counting fence in 1983.

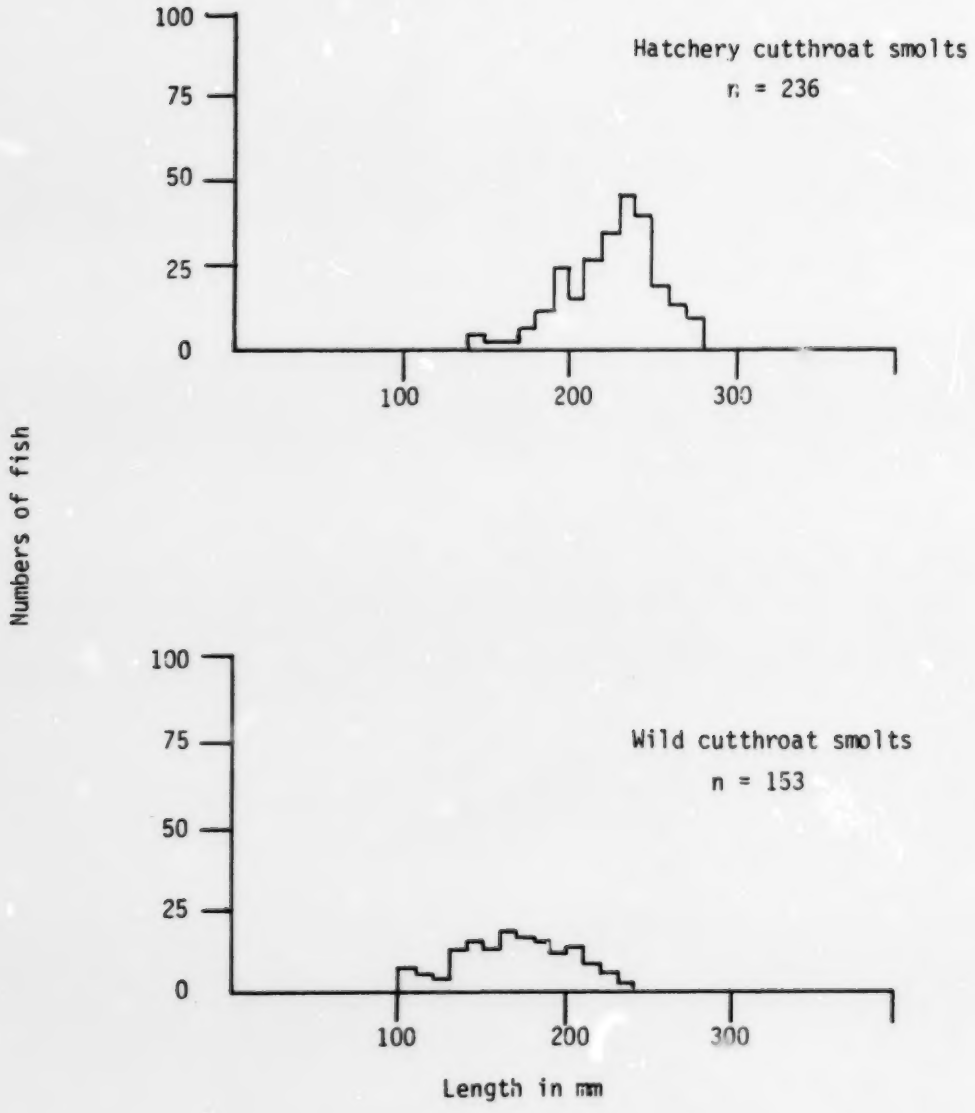


Fig. 6. Length frequency of cutthroat migrating downstream at Little Campbell counting fence in 1983.

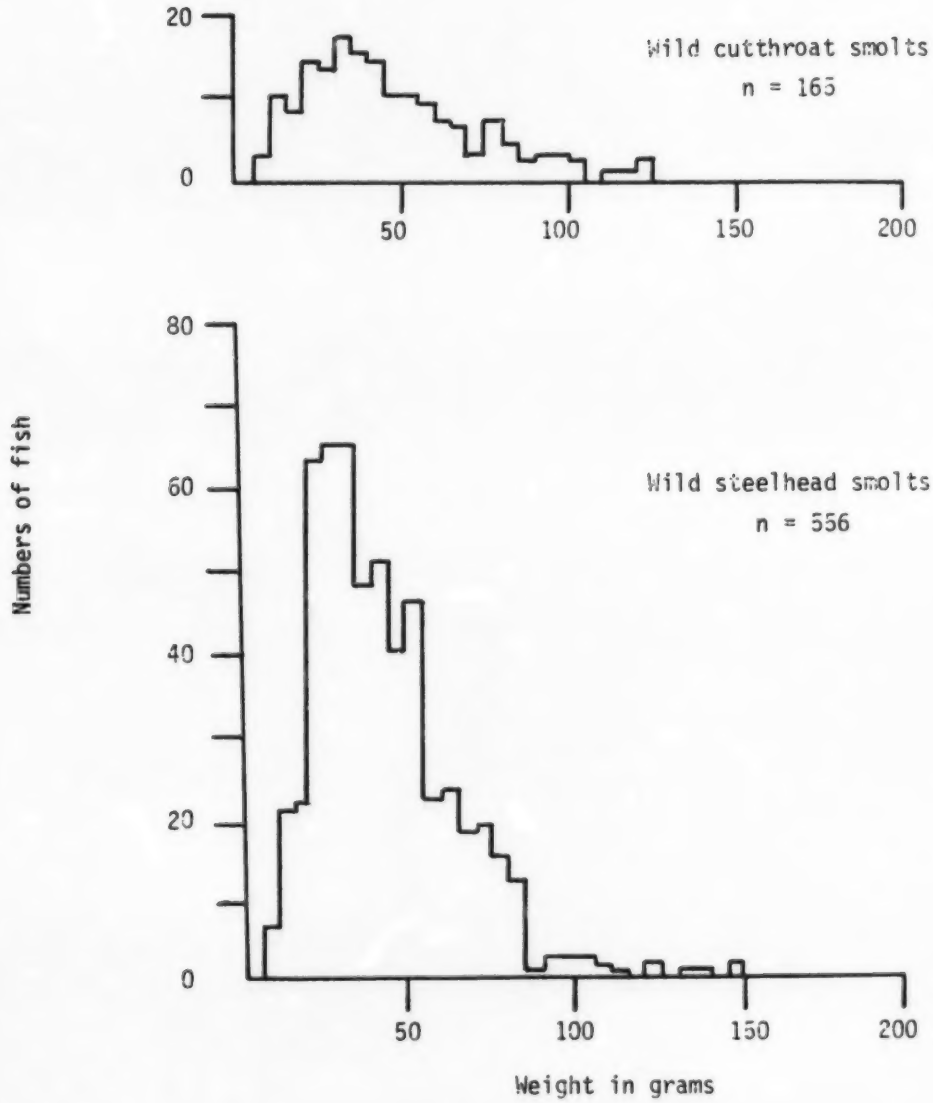


Fig. 7. Weight frequency of steelhead and cutthroat smolts migrating downstream at the counting fence in 1983.

Appendix I. Little Campbell River stocking history

Year	Lib. Date	Species	No./kg	Total kg	Source	No. of Fish	Clip	Release Sites
1981								
Smolt	March 9	STHD	18.3	125	L.C.	2284	CWT	16th & 24th Ave
0+	July 3	STHD	555	6.3	L.C. Serpentine Murray	3500	Unmarked	Upper Reaches
1982								
Smolt	April 30	STHD	8.9	453	Mud Bay	4029	CWT	24th & 204th St 24th & 200th St 16th & 194th St
0+	July 15	STHD	623	8.92	L.C.	5557	Unmarked	16th between 184th & 200th Sts
Smolt	October 28	CUT.	28.2	17.7	Mud Bay	500	AD L Max	20th & 200th St
1983								
Smolt	April 20	STHD	7.86	308	L.C.	2421	CWT	16th & 194th St
Smolt	April 20	STHD	7.86	308	L.C.	2421	CWT	24th & 200th St
Smolt	April 20	STHD	7.86	266	L.C.	2092	CWT	24th & 204th St
Smolt	April 20	CUT.	8.5	235	Mud Bay	2000	R Max, L Max	with steelhead lib.
0+	May 25	STHD	960	4.2	L.C.	4032	Unmarked	16th & 200th St
0+	June 23	CUT.	542	9.52	Mud Bay	5157	AD R Max	Upper Reaches
0+	July 6	STHD	928	3.51	L.C.	3275	Unmarked	16th & 194th St 20th & 196th St
Proposed								
1984								
Smolt		STHD				5000	AD	Below fence
0+		STHD				10000	L Max	Above 200th
Smolt		CUT.				3000	R Max	U/S of fence - 16th
Smolt		CUT.				5000	AD	D/S of fence
0+ Oct.		CUT.				5000	AD	Tribs U/S of fence

Appendix II. 1982 trapping results - Little Campbell River.

Total number of juvenile steelhead and cutthroat trout migrating downstream of the Little Campbell River counting fence in 1982

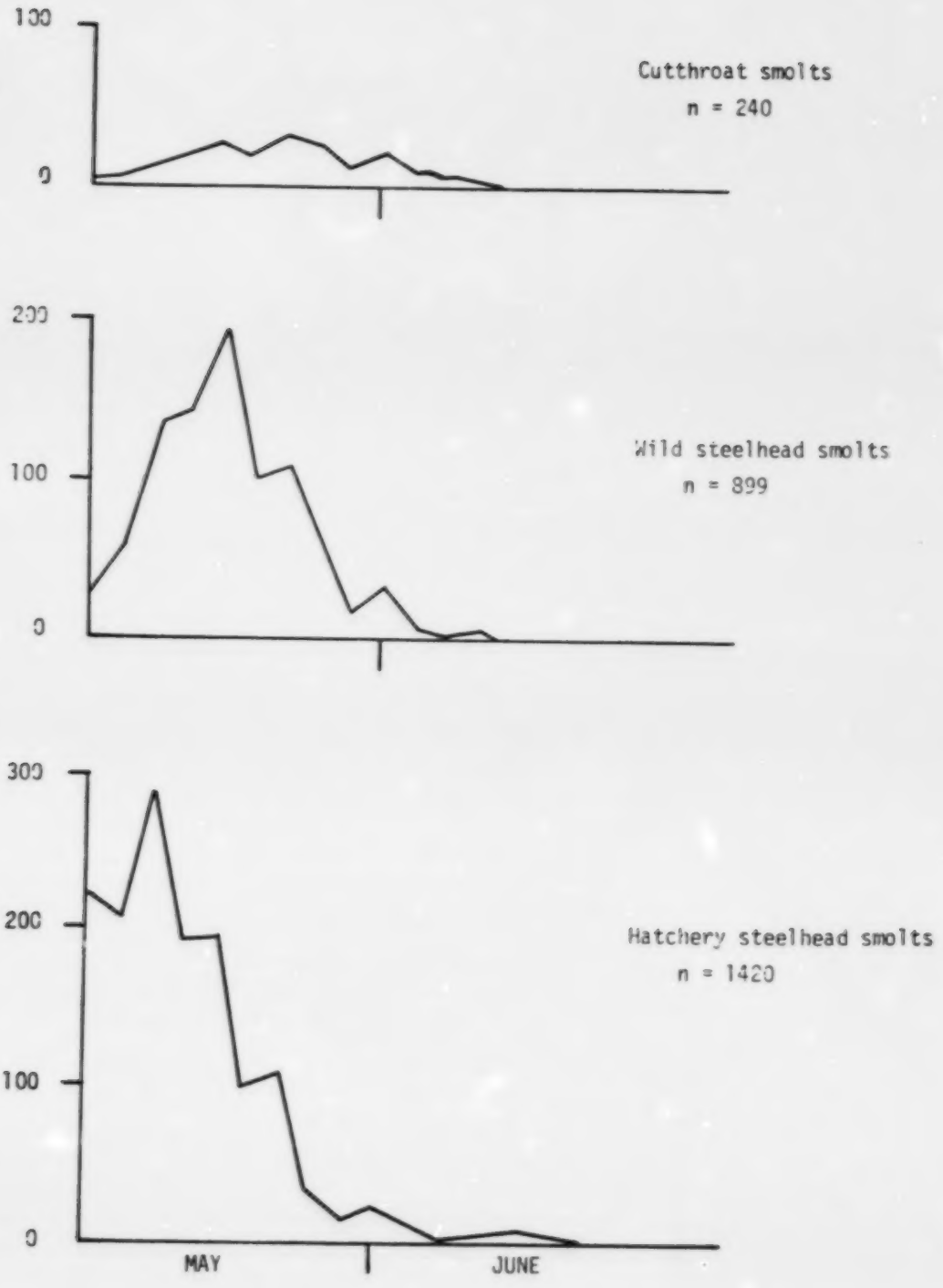
		Steelhead	Cutthroat
Wild smolts	Actual	1035	237
	Expanded	1242	287
Wild parr	Actual	112	19
	Expanded	134	23
Hatchery smolts	Actual	1428	
	Expanded	1714	

Age composition of steelhead and cutthroat smolts migrating downstream at the Little Campbell River counting fence in 1982

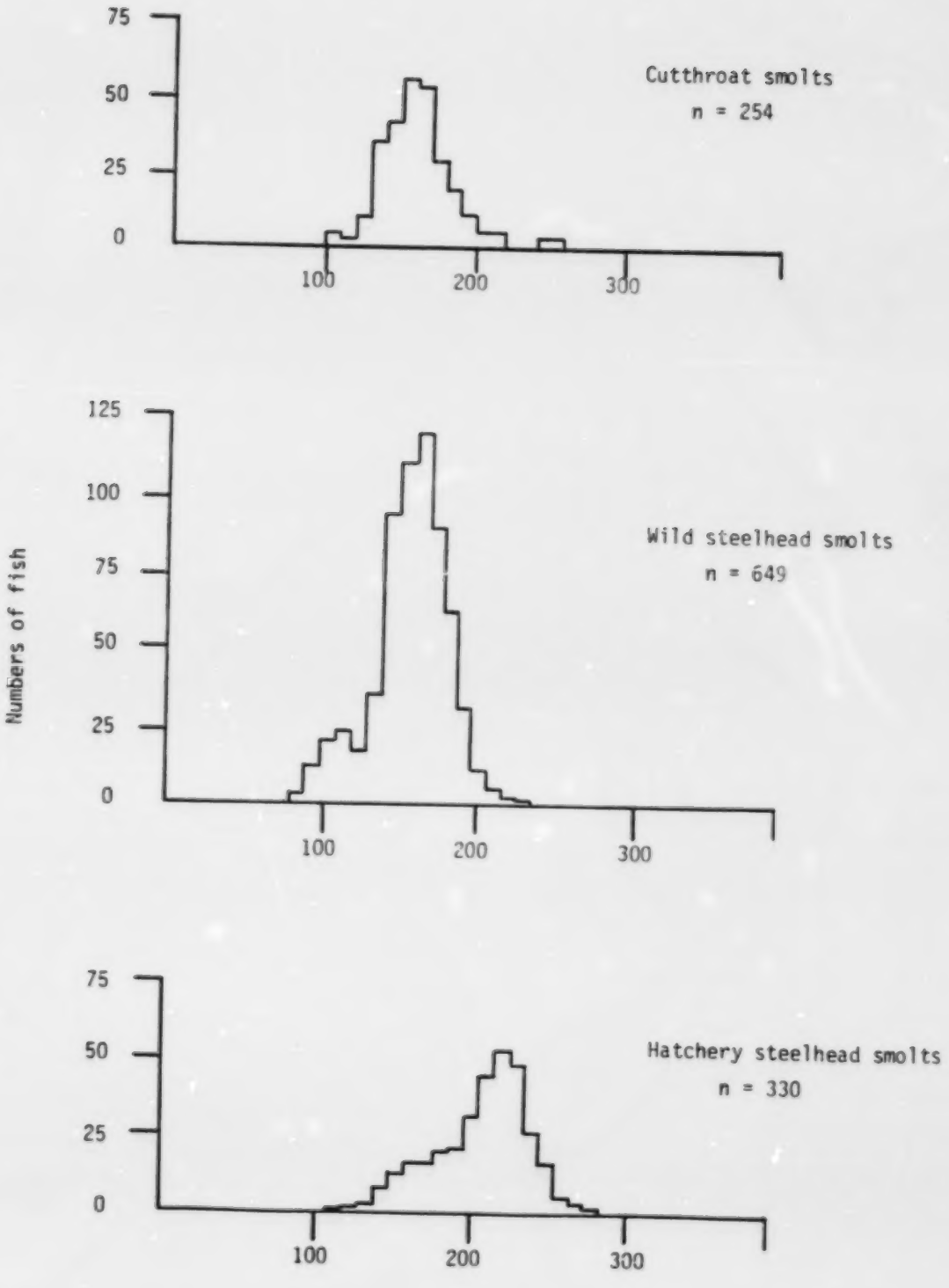
	Steelhead			Cutthroat		
Age	1	2	3	1	2	3
Number	78	53	0	35	27	0
Percent	59.5	40.5	0	56.5	43.5	0

Mean length and weight at age of steelhead and cutthorat smolts migrating downstream at the Little Campbell River counting fence in 1982.

	Steelhead		Cutthroat	
Age	1	2	1	2
Length (mm)	157.3	175.8	151.7	173.7
Standard deviation	16.9	18.3	14.6	18.3
Number	78	53	35	27
Weight (grams)	36.6	49.8	31.4	46.5
Standard deviation	11.1	16.4	9.2	15.8
Number	78	53	35	27
Condition Factor	.94	.92	.90	.89

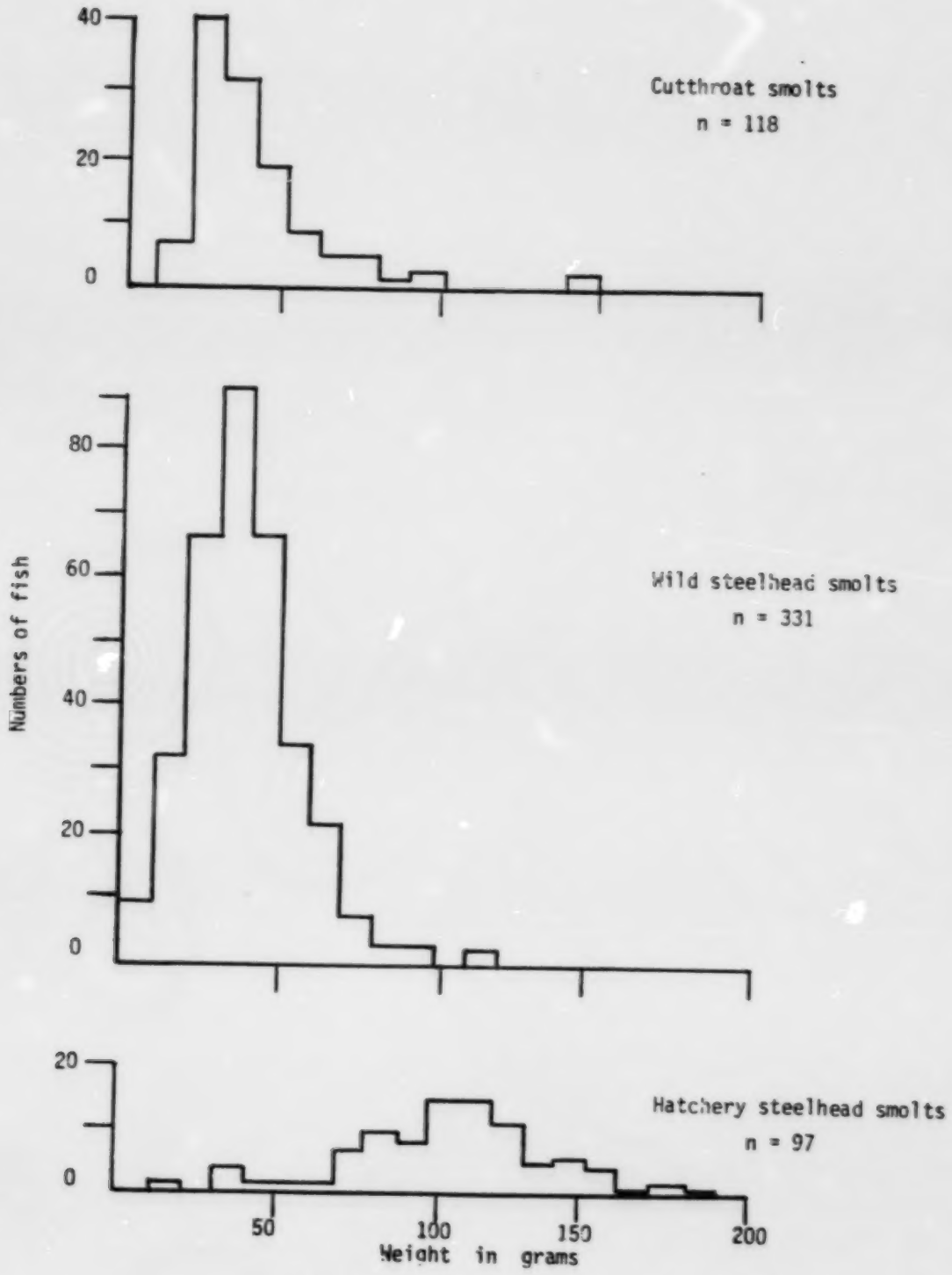


Seaward migration of steelhead and cutthroat smolts from the Little Campbell counting fence in 1982.



Length frequency of steelhead and cutthroat smolts migrating downstream at Little Campbell counting fence in 1982.

Appendix II - Cont.



Weight frequency of steelhead and cutthroat smolts migrating downstream at Little Campbell counting fence in 1982.

Appendix III. Population densities (no./m^2) of juvenile salmonids in the Little Campbell River in 1982 (July).

	Coho Fry	Trout Fry[1]	Steelhead Parr (1+)	Cutthroat Parr (1+)
Section A (0.3 km upstream)	0.46	2.5	0.12	0.002
Section B (ca. 7 km upstream)	0.57	1.3	0.03	0.011

[1] primarily steelhead; to be rechecked by electrophoresis

List of previous Fisheries Technical Circulars

1981 54 Facchin, A. and G. King - Lake Survey and Stocking Records for the Kootenay Region of British Columbia. Vol. 1. Management Units 4-1 to 4-22.

1982 55 Facchin, A. and G. King - Lake Survey and Stocking Records for the Kootenay Region of British Columbia. Vol. 2. Management Units 4-23 to 4-40.

1983 56 Billings, S. J. - Steelhead Harvest Analysis, 1981-82.

1983 57 Facchin, A. and G. King - Lake Survey and Stocking Records for the Okanagan Region for British Columbia.

1983 58 Facchin, A. Hooking Mortality of Fly-Caught Duncan River Rainbow Trout (Salmo gairdneri) in Harper Lake, British Columbia.

1983 59 Billings, S. J. Steelhead Harvest Analysis, 1982-83.

1984 60 Andrusak, A. and E. A. Parkinson. Food Habits of Gerrard Stock Rainbow Trout in Kootenay Lake, B. C.

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1978 73 Slaney, P. A., T. G. Halsey and A. F. Tautz. Effects of Forest Harvesting Practices on Spawning Habitat of Stream Salmonids in the Centennial Creek Watershed, British Columbia.

1979 74 Sebastian, D. C. Life History Characteristics of Mission Creek Rainbow Trout Based on Scale Analysis.

1980 75 Stringer, G. E., A. F. Tautz, T. G. Halsey and C. Houston. Further Development and Testing of a Lake Stocking Formula for Rainbow Trout in British Columbia

76 Smith, H. A. & P. A. Slaney. Age, Growth, Survival and Habitat of Anadromous Dolly Varden (Salvelinus malma) in the Keogh River, British Columbia.

77 Ludwig, B. A Morphological and Biochemical Comparison of Artificially and Naturally-Reared Salmonids.